U. S. DEPARTMENT OF AGRICULTURE

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ROOF COVERINGS *for* FARM BUILDINGS *and* THEIR REPAIR

THE ROOF is a very important feature of all kinds of buildings since it is depended on to protect the interior, and to some extent the exterior, from the effects of weather.

Roof repairing is too often neglected. Many small defects that can be readily repaired if the work is done promptly are permitted to cause damage to the interior of the building and shorten the life of the roof itself.

This bulletin describes the common types of roof coverings classified as rigid shingles, bituminous roofing, metal roofing, and canvas roofing. The essential steps to be taken in making repairs are described and information given regarding certain roofing details.

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ROOF COVERINGS FOR FARM BUILDINGS AND THEIR REPAIR

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INTRODUCTION

AS NO PART of a structure is of greater importance in protecting the building and its contents than the roof, it should be kept watertight at all times. A farm housing survey made in 1934 by the United States Department of Agriculture in cooperation with the agricultural colleges of 46 States indicated that the roofs of approximately 40 percent of the farm houses visited needed to be repaired or replaced.

The object of this bulletin is to describe types of roofing in common use, to suggest methods of locating leaks and making simple repairs, and to describe the salient features to be observed in reroofing. By observing the suggestions offered herein farmers should be able to keep the roofs of their buildings watertight.

TYPES OF ROOFING

RIGID SHINGLES

Various kinds of materials are formed into small rigid units featuring richness of color, durability, variety of pattern, or some special method of fastening to the roof. Clay shingles, clay tiles, cement shingles, molded-asbestos tile, and shingles of different kinds of metal are sometimes used. The types of rigid shingles commonly used on farm structures are of wood, slate, and asbestos cement.

WOOD SHINGLES

If of a durable species and properly laid, wood shingles will provide a satisfactory, attractive, and comparatively low-cost roof having considerable insulating value.

[1] Acknowledgement is made of the valuable assistance rendered by Max J. LaRock, assistant architectural engineer, Division of Structures.

The best commercial wood shingles are No. 1,[2] all heart, all edge-grained, and strictly clear. Southern cypress, redwood, and the cedars are in the highly decay-resistant group; northern white pine and southern yellow pine are in the moderately decay-resistant group. Ordinary shingles are of random widths varying from 2½ to 14 inches, and are packed in bundles each equivalent to 250 shingles 4 inches wide. Dimensional shingles can be had, sawed to uniform widths of 4, 5, and 6 inches.

Shingles are commonly manufactured in lengths of 16, 18, and 24 inches. In laying shingles, a definite length of the butt is exposed to the weather, depending on the slope of the roof and the length of the shingle. The recommended thickness of the 16-inch shingle is 5/2 (meaning that 5 butts will measure 2 inches over all); of the 18-inch shingle 5/2¼; and of the 24-inch shingle 4/2. For 16- and 18-inch lengths a 4-inch exposure is recommended on one-fourth pitch [3] and 5 inches on full pitch; 24-inch shingles are laid 6 to 7½ inches to the weather. The exposures on intermediate pitches should be proportionate between these limits. It will be difficult to keep a shingle roof watertight if the slope is less than one-fourth pitch.

In warm humid climates wood shingles on new roofs are commonly nailed to slats (fig. 1), so as to permit of ventilating the under side. Other advantages of the slat roof are its lightness and low cost. The slats should be 1 by 4 inch strips spaced approximately 6 inches center to center, so that nailing can be done about 2 inches above the weather line of the shingles. In cold climates, where a warm roof is needed, the shingles are commonly laid over tight board sheathing previously covered with waterproof paper; sometimes insulation board is used under slats in place of the tight sheathing. The tight roof furnishes better insulation and permits less air infiltration.

If dry shingles are soaked prior to being laid, less trouble will be experienced from improper spacing. Dry shingles should be spaced one-fourth of an inch apart, and green or wet ones about one-eighth of an inch apart, to permit of the swelling that occurs during damp weather. Each shingle should be fastened with two nails about five-eighths of an inch in from the edges and about 6 inches from the butt. Driving nails into the middle of a shingle or atmospheric changes may cause it to split. It is advisable to split wide shingles before laying them.

Joints should be broken at least 1½ inches, and all nails should be covered. Shingles should be doubled at all eaves and should project about one-half to three-fourths of an inch beyond the edge of the eaves. As the work progresses, the coursing should be checked to keep the shingle rows parallel with the eaves so as to avoid any great difference or unevenness in the exposure of the last few courses.

Methods of installing flashings, which should be of best quality 26- or 24-gage galvanized metal, or heavily coated IX flashing tin dipped or painted on both sides with red lead, are shown in the various illustrations. Details of finishing ridges and hips are clearly shown in Figure 2. (For more complete discussion see p. 26.)

[2] See grading rules of the lumber manufacturers' association that handles the species of wood desired.

[3] The pitch of a roof is found by dividing the rise of a rafter by twice its horizontal run.

Where low-grade flat-grained shingles are used to lessen the first cost of semipermanent structures, greater service will be secured if they are laid with the bark side (that which was nearest the bark in the tree) exposed, as that side weathers better than the heart side. Shingles so laid are not so likely to become waterlogged nor to turn up at the butt.

The commonly used creosote stains[4] have little if any retarding effect on checking and very slight value in retarding decay. Their

FIGURE 1.—Method of laying wood shingles over slats. Note the variation in the projection of the butts made to produce a different effect from that obtained when the butts are lined up. The cap flashing at the chimney is turned back for convenience in placing the base flashing.

principal value is for decoration. After a short period of exposure there is little left but pigment. At this stage the shingles can be painted without danger of discoloration. Shingle stains rich in coal-tar creosote have much more preservative value than the light-colored shingle stains which usually contain little if any of this oil. Shingles treated with coal-tar creosote, or with a stain containing any considerable percentage of this oil, cannot be satisfactorily painted, as

[4] See Farmers' Bulletin 1452, Painting on the Farm, pp. 19 and 32 for stains, and p. 11 for fireproofing paint.

the creosote will bleed through the paint even after several years of exposure. Frequently only the butt ends are dipped in the stain for a distance of 6 inches prior to being laid, but it is better practice to dip them to within 3 inches of the tapered end. Dipping is more effective than brush applications; however, brush coats are often applied for additional protection after the roofing has been exposed for several years.

Oil paints and stains provide a smooth surface upon which sparks will not lie, and reduce the warping of shingles. Accumulations of paint at the butt may form a slight ridge sufficient to hold water;

FIGURE 2.—Method of finishing hips and ridges.

also, paint, being less porous than stain, does not permit the wood to dry as readily if it becomes wet, and thus may promote decay. In certain instances where the surface is rough, paint may be advisable.

SLATES

Slates make an attractive and durable roof covering and can be obtained in various colors. The best slates have a somewhat metallic appearance, do not absorb water, and are strong. It is not feasible here to give the classifications of slate regarding color

and quality, but a B-grade slate is reasonable in cost and has sufficient durability for farm structures.

Some dark slates upon exposure will fade to a gray color, and as the change is not always uniform it may result in an undesirable appearance. Certain green slates may become buff or brown after a few months' exposure, but the change is sometimes considered desirable, and it does not detract from the quality of the slate.

Certain sizes of slate are at times more plentiful than others, and certain sizes usually cost more than other sizes of the same grade. It will be economical both in cost and time of delivery to permit the use of a range of sizes and random widths. Smaller sizes should be selected for smaller surfaces even when larger sizes are desired for the larger surfaces of the same building. The distance from the quarries influences the cost of slate; near the quarries the cost may be comparable with less durable roofings. Commercial sizes vary from 6 by 10 inches to 14 by 24 inches, with thicknesses ranging from one-eighth to one-fourth of an inch. Slate three-sixteenths inch thick and 8 by 16, 9 by 12, or 9 by 18 is commonly used.

Holes must be punched or drilled in slate for the nails. This may be done on the site or at the quarry, and costs about 35 cents per hundred pieces. Drilling is considered the best method. The holes are made either at the head or to come one-half inch above the head of the slate below, the distance from the end depending on the length of the slate and the amount exposed (fig. 21). If at the head, the holes should be 1 inch from the top. The holes should be 1½ inches from the edges.

Slate are laid in much the same manner as are wood shingles, but as they weigh between 700 and 900 pounds per square [5] the roof framing should be stronger for them than for wood shingles. On the main part of a house the roof should slope at least 6 inches and preferably 8 inches to 1 foot, though on porches or minor buildings the slates are sometimes laid on flatter slopes. If it is necessary to lay slates on house roofs at slopes less than 6 inches per foot the lap should be increased. Slate should not be used on slopes of less than 4 inches per foot. Slates should preferably be laid on tight and smooth board sheathing (either plain or tongued and grooved) covered with 30-pound tarred or asphalt felt. Rosin-sized paper is not suitable.

Sometimes roofing slats, as described under wood shingles, are used instead of tight sheathing where insulation is not required and if low cost is a consideration. Such slats should be a full 1 or 1¼ inches thick.

Each slate should lap the slate in the second course below by 3 inches, and be fastened with two threepenny or fourpenny copper or other high-grade rust-resistant nails 1¼ to 1½ inches long. The nails should not be driven tight as there is danger of cracking the slates. Since the life of the roof depends on the fastenings it is poor economy to use nails which will not last. The slate should be doubled at the eaves, short slates being used or the first course laid with the long side of the slate parallel to the eaves. The top courses at ridges,

[5] The area of a roof is usually expressed in "squares" of 100 square feet.

and 2 feet from gutters and 1 foot from hips and valleys should be laid in elastic roofer's cement spread about one-fourth to three-eighths of an inch thick. The flashing should be 16-ounce soft copper, no. 9 zinc, or 3-pound hard lead. Hips and ridges are frequently finished "Boston style", which is similar to the reshingling shown in figure 2.

ASBESTOS SHINGLES

Asbestos shingles are made by compressing asbestos fiber and Portland cement under great pressure. They are strong, durable, and fire-resistant.

The natural color of this shingle is similar to Portland cement and produces a roof surface that is rather cold in appearance. To meet architectural requirements, shingles are now made in a wide variety of colors and surface textures. The color is produced by veneering the exposed surface, by incorporating mineral pigments throughout the body of the shingle, or by pressing fragments of colored slate or other materials into the exposed surface. There is no standard by which to judge between the merits of the many variations, and the small buyer should be guided by the reputation of

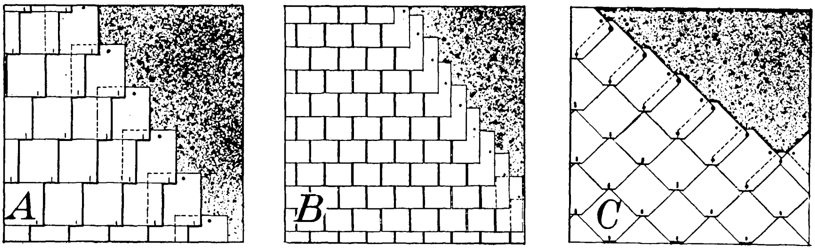

FIGURE 3.—Types of asbestos shingles: *A*, Dutch or side lap; *B*, American; *C*, French or hexagonal.

the manufacturer or by the service given on buildings in his locality. The roof framing should be checked for strength, and the general directions given for slate shingles should be followed. Special starting shingles are required.

There are three chief types of asbestos shingles according to shape and method of application; the side lap or Dutch lap (fig. 3 *A*); the rectangular or American (fig. 3 *B*); and the hexagonal or French (fig. 3 *C*).

The side-lap shingle (or Dutch lap) is approximately 16 by 16 inches and can be had three-sixteenths or one-fourth of an inch thick, weighing 300 to 320 pounds per square. Figure 4 shows the method of laying. This shingle is laid with one-fourth or one-third side lap. The one-third lap is preferred because the shingles look better when a smaller section is exposed, and a tighter roof results, but a somewhat lighter weight and lower cost is obtained when one-fourth lap is employed.

More detailed instructions for laying asbestos shingles according to the various methods may be obtained from manufacturers and dealers.

The rectangular or American shingle needs no special comment as it is applied in the same way as slate. The most used size is

about 8 by 16 inches, and can be had tapered in thickness if desired. They weigh approximately 465, 565, and 660 pounds per square if three-sixteenths, one-fourth, or five-sixteenths of an inch thick, respectively.

The hexagonal shingle is approximately 16 by 16 by three-sixteenths inches, weighs about 275 pounds per square and is held in place by nails and storm anchors. These shingles so laid cost less, require fewer shingles per square of roof, and make a lighter weight

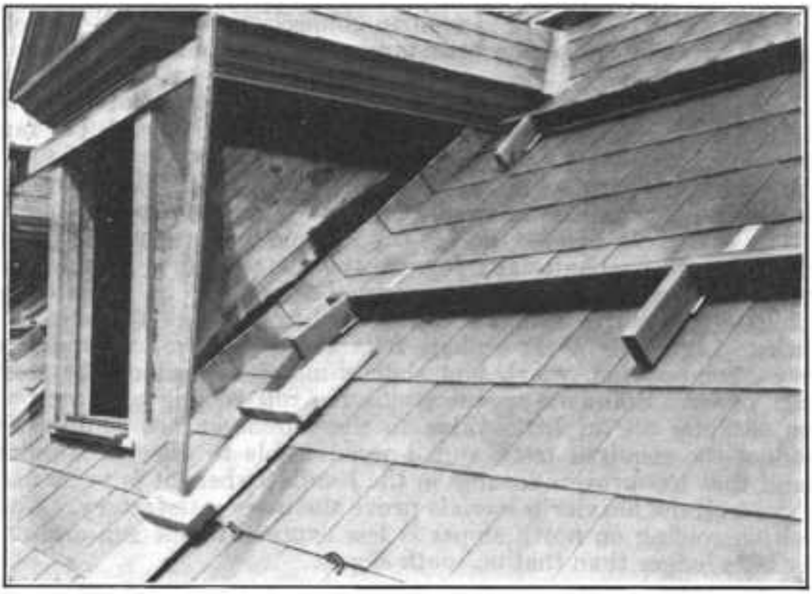

FIGURE 4.—A roof covered with side-lap asbestos shingles. The metal strips holding the scaffold should be clipped off even with the edge of the shingle when the roofing has been completed. Note the snow guards protruding between the shingles near the bottom.

covering than the rectangular shingle. Some architects object to the appearance caused by the diagonal lines and the large units.

BITUMINOUS ROOFINGS

TYPES

Bituminous roofing in one of its many forms is commonly used for covering moderate-cost buildings on farms. It is used in four general types: (1) plain impregnated felts, often referred to as tar paper, (2) heavily coated felts in rolls, known as roll, prepared, or ready roofing, (3) shingles and shingle strips, frequently called composition or asphalt shingles, and (4) built-up coverings, commonly referred to as tar-and-gravel roofing.

The basis of these roofings is a felt composed of rag, paper, jute, or similar material, made on a paper-making machine. The felts are passed through a vat of hot tar or asphalt until saturated. Most ready roofings are composed of two or more layers of asphalt-saturated felt coated with bitumen, and many are surfaced on the wea-

ther side with mineral granules, usually slate or sand, though sometimes mica or talc. The under side is generally dusted with mica or soapstone. These roofings vary from the lighest felts made of cheap materials to several-ply sheets too heavy to be rolled. Some of these coated felts are cut up into shingles of various sizes and patterns. Variations in color are dependent chiefly on the color of the embedded granules.

Coal-tar-impregnated felt is not usually employed for ready roofing because of the difficulty in preventing the layers from sticking together when rolled. It is used in connection with built-up roofing, for covering temporary structures, and occasionally as sheathing paper.

Impregnated asbestos felts and metal-coated waterproof sheathing papers are also available, but are not commonly used on farm structures.

A material often confused with impregnated felts is rosin-sized sheathing paper. This is merely a heavy building paper, generally red in color. It is used under tin roofing, because unneutralized acids of tar or asphalt felts corrode the metal, and also under tar-and-gravel built-up roofing over wood sheathing to prevent tar, which might run in summer from trickling through the sheathing cracks. Lightweight tar-asphalt felts are generally laid under asbestos, composition, wood, and slate shingles instead of the rosin-sized paper. Standard specifications for roll roofing and composition shingles are of little value to the purchaser not equipped to conduct the required tests, and it is advisable to select a standard brand that has proven durable in the locality where it is to be used. In general, the heavier materials prove the more satisfactory. Composition roofing on north slopes is less exposed to the sun and usually lasts longer than that on south slopes.

LIGHTWEIGHT FELT ROOFING

Frequently, lightweight felts are used to cover sheds and chicken houses. This type of roofing is not suitable except as a very temporary covering because it is easily torn by the wind (fig. 5), especially if the wind can blow up through cracks in the sheathing.

ROLL ROOFING

Roll roofing, when of good quality and properly laid over tight sheathing, forms a low first-cost covering suitable for the smaller farm buildings (fig. 6). The heavier grades might be used for re-roofing over old asphalt shingles provided the shingle surface can be made fairly smooth. While combustible after a fire has gained headway, roll roofing is not readily ignited by hot brands, especially if the slope of the roof is sufficient to prevent the lodgment of glowing embers.

The most common method of laying is to stretch the sheets parallel to the eaves (fig. 7), starting at the lower end and taking care to avoid wrinkles and bags. The next layer should be lapped 2 or 3 inches over the edge of the lower sheet, and the ends of adjoining strips lapped 6 inches. All laps should be cemented together and then fastened to the wood sheathing with large-headed galvanized

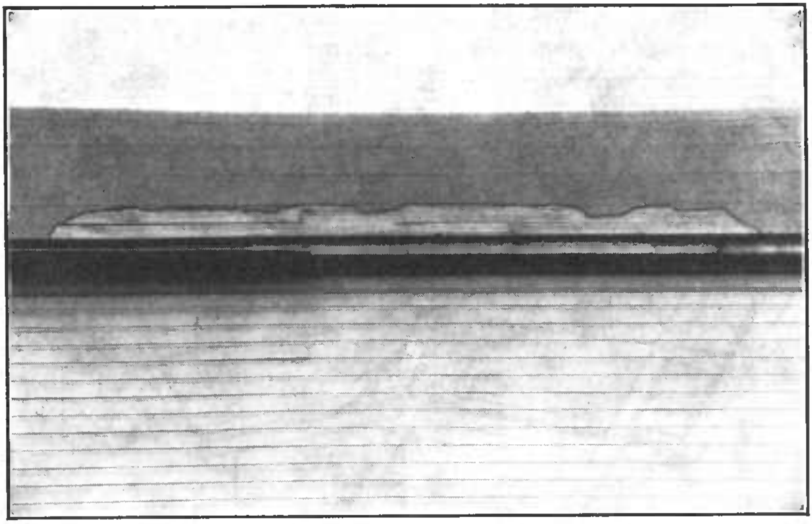

FIGURE 5.—Lightweight felt roofing torn by the wind blowing through the wide joints between the sheathing boards.

FIGURE 6.—A poultry house covered with roll roofing. Note the usual method of nailing the edges over the eaves and gables. The location of the building is unfortunate as swaying branches wear the roofing.

nails spaced about 2 to 3 inches apart, care being taken to avoid driving nails into cracks between the boards. If nails are accidentally driven in cracks they should be pulled out and the nail hole

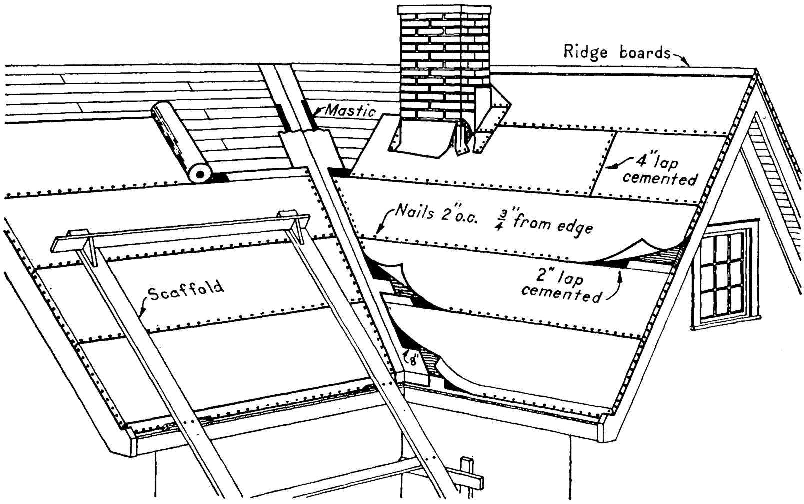

FIGURE 7.—Roll roofing laid parallel to the eaves; note the scaffold.

patched. Tin caps are not recommended because they corrode quickly and leave the nail head protruding so that the roofing is easily torn off by the wind. Generally, enough cement and nails for one roll are included in the package with the roofing.

Roll roofing when laid with the slope of the roof (fig. 8) can be more easily stretched smooth before being nailed in place. Wood

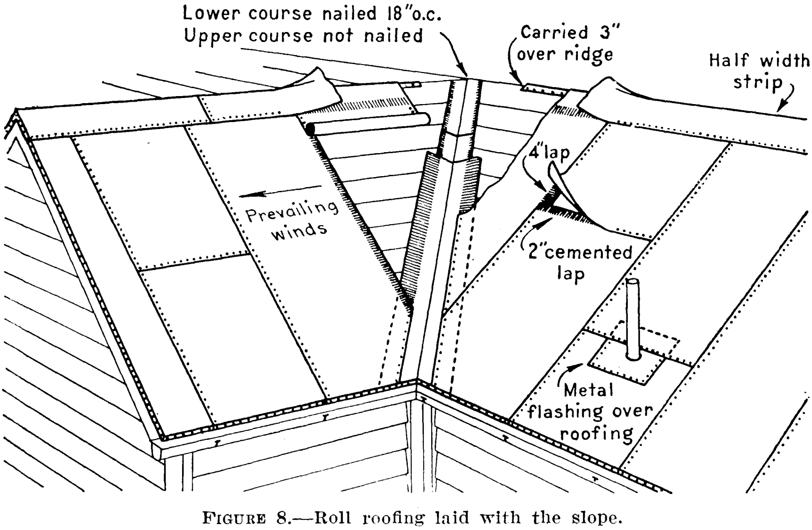

FIGURE 8.—Roll roofing laid with the slope.

battens or the patented metal strips, if used over the long laps, afford better protection to the roofing against the probability of being torn by the wind.

Necessary flashings are generally of the same material as the roofing. Two thicknesses are used (figs. 7 and 8), and made tight by cementing all laps and edges with plastic cement or mastic. Flashings at chimneys are wedged and calked into the mortar joints. It is best to use rust-resistant metal chimney flashings on all but the cheapest work (p. 26).

Figure 9 shows a better method of fastening roll roofing at the eaves and gables than the usual practice of nailing into the edge of the sheathing as shown in figure 6. Barbed or cement-coated nails are best for nailing the battens.

A variation of the regular roll roofing can be had which should prove very useful. This is a type coated with mineral granules for only 1 inch more than half its width, the remaining width being uncoated. (The uncoated portion is referred to as a 17-inch or 19-inch selvage.) The advantage of this material is that it can be laid in two thicknesses which are cemented together but have the mineral coating where exposed to the weather.

Copper foil cemented on the top ply of composition and built up roofings, to give greater durability, has recently come into use.

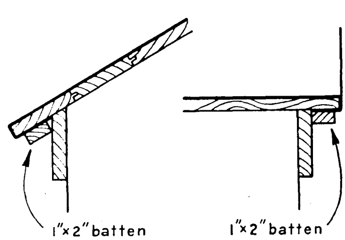

FIGURE 9.—The use of battens for holding the edges of roll roofing at eaves.

ASPHALT SHINGLES

Asphalt or composition shingles have become a very important and widely used covering because of their moderate cost, light weight, and relative durability. They can be had as single shingles or in strips consisting of several units joined together. A large variety of shapes or patterns and colors are available. The strips can be laid with less labor than individual shingles. A common type is a four-shingle strip 32 or 36 inches long by 12½ inches wide, having cut-outs 4 inches deep and one-half inch wide which produce the same appearance on the roof as when individual shingles are used. Ordinary 12½-inch shingles are laid with 4-inch exposure. These shingles have the same characteristics as heavy roll roofing. Lightweight composition shingles or heavier shingles with too large exposure are likely to curl badly on the roof after weathering. To reduce curling when a large exposure is desired, as in reroofing without removing the old covering a number of types of "lock-down" composition shingles are made. While this feature adds to the efficiency of the covering the appearance is often less satisfactory than that of the plain shingles. The general methods of applying different types are illustrated in figures 10 and 11, and in directions for laying furnished by the manufacturers.

BUILT-UP ROOFING

Built-up roofing consists of several layers of 15-pound impregnated felt lapped and cemented together with a bituminous material and covered with a layer of small-sized gravel or slag. Tar pitch must be used as the cementing material with tarred felt, and asphalt with asphalt felt. Roofs are classed as 3-, 4-, or 5-ply, according to

the number of layers of felt. Figure 12.1, illustrates the method of laying a 5-ply roof. The 3-ply roofing costs less than 5-ply but will not last so long.

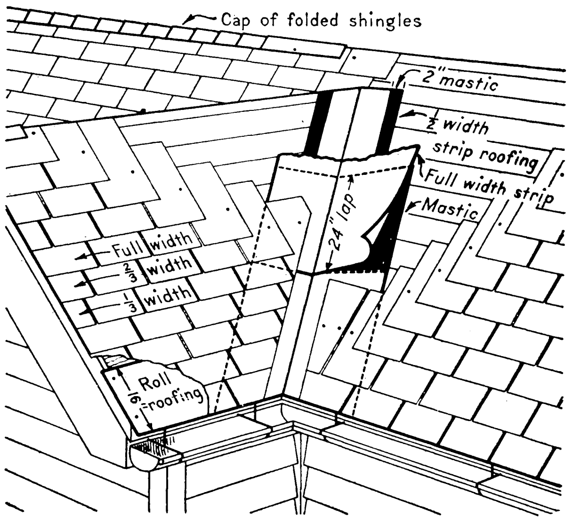

FIGURE 10.—Method of laying single asphalt shingles.

Tar is more affected by heat and for this reason cannot be used on as steep a slope as can asphalt.

Built-up bituminous covering is suitable on roofs sloping from one-half to 2 inches per foot. On greater slopes the roofing may

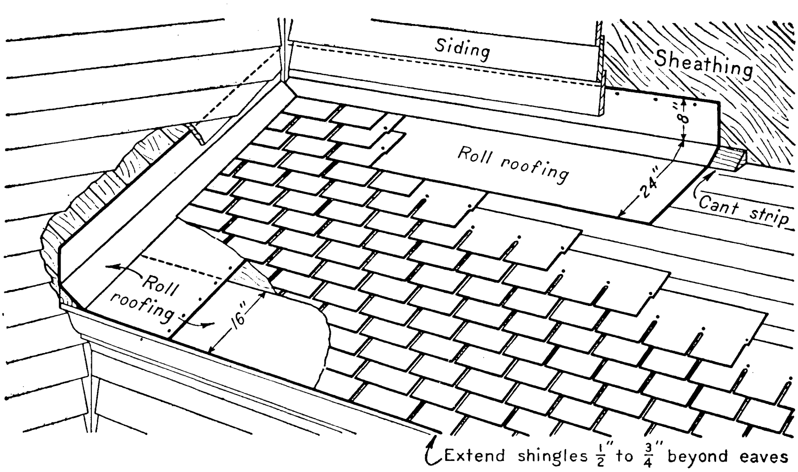

FIGURE 11.—Method of laying four-shingle strips.

slip in hot weather, and the gravel is difficult to keep in place. On lesser slopes drainage is difficult owing to unevenness of the roof surface. The gravel covering is used to protect the tar or asphalt from disintegration by the elements and to afford fire resistance.

A metal gravel stop (fig. 13) should be used at the eaves to prevent gravel from being washed away.

Parts of sheathing boards containing loose knots or other flaws should be discarded, or the knot holes and large cracks should be covered with sheet metal nailed in place. Care should be taken that the roofing is not installed over ragged or sharp corners. This

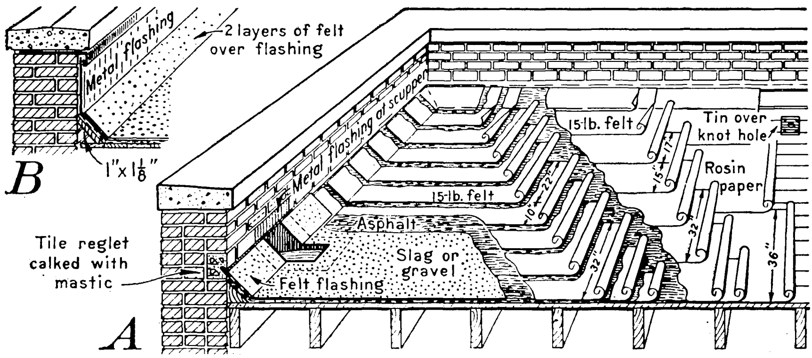

FIGURE 12.—*A*, Five-ply built-up roofing; *B*, detail of flashing under coping.

can be avoided by the use of cant boards (fig. 12) at the intersection of the roof with vertical surfaces. The roof should be carefully flashed at junctions with walls, particularly in regions of heavy snows. With low parapet walls the cap flashing may be laid under the coping (fig. 12, *B*). In brick walls the cap flashing may be built into the brickwork or calked into a special tile. When pouring concrete walls, provisions should be made for a reglet or groove for holding the cap flashing.

This type of roofing should be considered more often on account of its high fire resistance, long life, and reasonable cost. When laid in accordance with the manufacturer's specifications and by skilled workmen, the 5-ply roof is generally guaranteed to give 20 years' service. Manufacturers, upon request, supply illustrated instructions for laying built-up roofing of 3, 4, or 5 plies over wood or concrete surfaces.

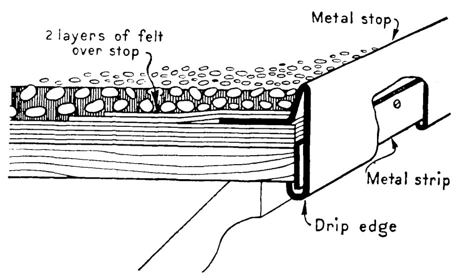

FIGURE 13.—Gravel stop of 26 gage galvanized metal on edge of sheathing. Stop is 1¾ to 2½ inches high on face.

COMMERCIAL PACKAGES

Tables 1 and 2 indicate the size and weight of commercial packages of bituminous roofing materials. Different manufacturer's products vary somewhat in weight, depending on the thickness, size, and pattern of the product and the kind and amount of coating.

TABLE 1.—*Average sizes and weights of bituminous roll roofings*

Material	Width	Area per roll	Weight per roll
	Inches	*Square feet*	*Pounds*
Tarred felt	32 and 36	216	50.
Do	32 and 36	432	50 and 65.
15-pound asphalt felt	32 and 36	432	65.
30-pound asphalt felt	32 and 36	216	65.
Slaters' felt	36	500	32.
Sheathing felt	36	500	35.
Red rosin-sized sheathing paper	36	500	20, 25, 30, and 40.
Roll roofing:			
Talc both sides	36	108	35 to 55.
Talc one side, mica other side	36	108	35 to 65.
Mica both sides	36	108	45 to 75.
Mineral surfaced	36	108	60 to 87.

TABLE 2.—*Average sizes and weights of bituminous shingles*

Shingles	Size, inches	Shingles per square	Weight per square	Shingles	Size, inches	Shingles per square	Weight per square
		Number	*Pounds*			*Number*	*Pounds*
Single	9 by 12⅜	370	240.	4-strip	12¼ by 36	100 to 120	240.
Do	12 by 16	224	315.	Do	10 by 36	100	190.
Side lap	12 by 16	112	135 to 155.				

METAL ROOFINGS

Metal roof coverings are light in weight and those types with locked or soldered joints can be used on very flat slopes with little danger of leakage. They are fire-resistant, and when properly grounded usually require little further precautions to make them reasonably safe from damage by lightning. Directions for grounding are given in Farmers' Bulletin 1512, Protection of Buildings and Farm Property from Lightning. If not grounded, metal roofs do not protect from lightning and may even increase the risk.

Metal roofs give little protection against either heat or cold, therefore on dwellings they should be laid over tight sheathing or one of the many forms of insulating material.

Sheet copper and zinc roofs are very desirable but are little used on farm buildings because of the high cost. They are laid like tin roofing.

TIN ROOFING

A tin roof of good material properly laid should last 40 to 50 years if kept well painted. This type of roofing is not readily applied except by men experienced in the use of the special tools that are needed. The salient features and general methods of application are given to point out the essentials required for a good tin roof.

The so-called "tin roofing" is really a soft steel, or sometimes a wrought iron, coated with either a mixture of lead and tin or tin only. When coated with the mixture it is known as "terneplate", and when coated with only tin as "bright tin."

Black sheet-metal plates or sheets were formerly dipped into a bath of the hot metal, which permitted heavy coats, but the present-day practice is to run the plates through rollers after they have been dipped so that the thickness of the coating can be varied.

The plates are made in different sizes, 10 by 14, 14 by 20, and 20 by 28 inches being the sizes most commonly used, and are obtainable in 2 thicknesses, IC and IX, the IX being the heavier. The thickness of the metal does not add appreciably to the life of the plates, as their durability is dependent on the thickness of the coating. The plates are sold in boxes of 112 sheets unless the weight exceeds about 300 pounds, in which case they are packed in multiple units of 14 sheets. Terneplates are generally used for roofing because they cost less than bright tin, and can be had with 8, 15, 20, 25, 30, or 40 pounds of coating per box, the 30-pound coating being much used. The IC thickness is best to use for the main roofing as it is easier to work and not so likely to cause expansion trouble as are the IX plates, which are generally used for flashings, valleys, etc.

The plates should be laid over tight sheathing, preferably tongue-and-groove lumber, well seasoned and of uniform thickness. The use of rosin-sized or other kind of sheathing paper, free of tar, is recommended to deaden the noise of rain and wind on the roof. It is not advisable to lay a tin roof over old tin, rotten shingles, or tar roofs. The under side of the metal should be painted with metallic brown or red lead; this is generally applied in the shop. Only rosin should be used as a flux in soldering.

When a roof slopes more than 3 inches per foot the metal should be laid with standing seams parallel to the slope. The 20- by 28-inch sheets generally are used, and may be made in the shop into long strips that can be rolled for convenient handling. In applying the metal, one edge of the strip is turned up at right angles 1¼ inches, then cleats spaced 8 to 12 inches apart are installed by nailing one end to the sheathing and folding the other end over the upstanding edge of the strip. The cleats used for fastening tin roofing to the sheathing are shown in figure 14*a*. The adjoining edge of the next strip should be turned up 1½ inches and the abutting upstanding edges locked, turned over, and flattened tightly against one side of the standing seam. These seams are not soldered, as are the flat seams used in making up the rolls. Standing seams should be straight, rounded neatly at the top edge, and stand 1 inch above the roof surface. The general method of laying standing-seam tin roofs is shown in figure 14. Light-gage plain galvanized steel is sometimes laid in the same manner.

When a roof slopes less than 3 inches per foot, heavily coated plates should be used, laid with flat seams. Sheets 14 by 20 inches should be used to provide sufficient stiffness against buckling. The metal should be laid so that the short dimension will be parallel with the eaves and so that all seams will be flattened upon the roof. The seams should be made by turning the edges of each sheet one-half inch, as shown in figure 15 and locking and soldering them together. If the sheets are laid one at a time they should be secured to the roof with 3 cleats (fig. 14, l), 2 on the long side and 1 on the short side. Sometimes the sheets are made into long lengths at the shop by locking and soldering the short edges together. The edges of the long lengths should be turned back one-half inch to permit the interlocking of adjacent strips, and secured in place with cleats. The interlocked seams of adjacent strips should be flattened and soldered watertight.

GALVANIZED-STEEL ROOFINGS

Galvanized-steel roofing has been used on farms for many years. Where good materials have been used and properly cared for, this roofing has been very economical and satisfactory, but where poor

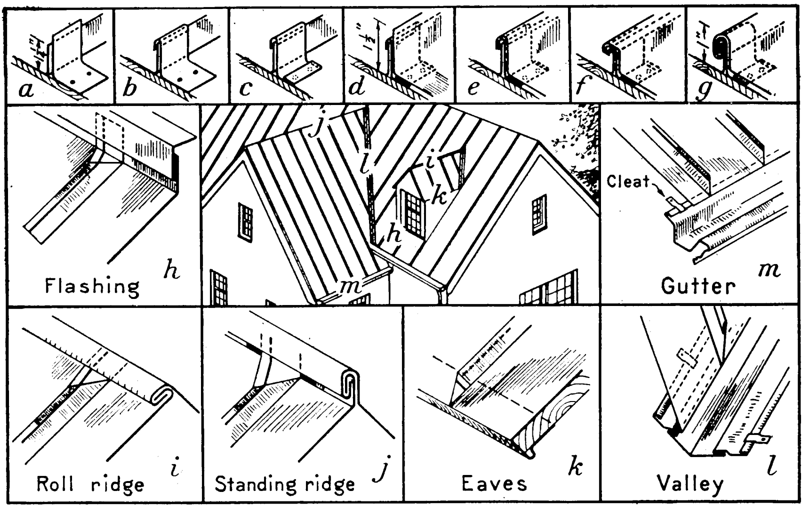

FIGURE 14.—Details of installing standing-seam roofs: *a* to *g*, inclusive, steps in the process of forming a standing seam; *h* to *m*, joints at breaks in the roof.

or light materials have been used and neglected they have failed in a few years from rusting. The durability depends chiefly on the protective coating, though alloy steels are more resistant to rust than is the common plain steel. Lightly galvanized sheets must be kept well painted in order to obtain reasonable use. Galvanized roofing with a guaranteed minimum coating of 2 ounces of zinc per square foot has recently been put on the market under a special "seal of quality." The heavy coating should insure long life under ordinary conditions, but eventually painting will be needed to insure maximum service. The paint should be applied before rusting begins. Galvanized steel roofings for farm buildings should be no. 28 gage or heavier. (The lower the gage number, the heavier the sheet.)

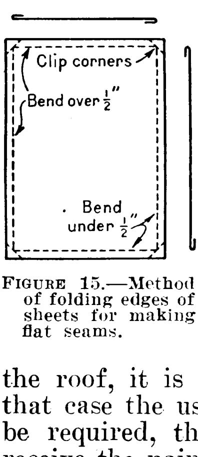

FIGURE 15.—Method of folding edges of sheets for making flat seams.

Galvanized metal when new is difficult to paint, and often is washed with vinegar or other solutions to provide a roughened surface to which the paint will adhere. Unless it is absolutely necessary to apply paint at the time of laying the roof, it is advisable to delay its application for a year. In that case the use of chemicals for roughening the surface will not be required, the metal will usually be in a good condition to receive the paint, and the zinc coating will not be damaged by the chemicals. Graphite and tar paints should be avoided on all metal coverings.

V-CRIMP STEEL ROOFING

V-crimp steel roofing is reasonable in cost, can be readily applied without special skill or tools, and looks very much like a standing-seam tin roof. It is manufactured in sheets approximately 26 inches wide (designed to cover a width of 24 inches allowing for side lap) and in lengths of from 5 to 12 feet. It can be had with 2, 3, 4, 5, and 6 **V** crimps; the 2- and 3-crimp cannot be made as watertight as the 4-, 5-, and 6-crimp, which provide for a double lap. The sheets should be laid on fairly tight sheathing and over rosin-sized sheathing paper. Triangular wood strips are usually furnished to be placed under the **V** crimp, and the sheets are held in place by nailing through the top of the **V** crimp and the wood strip. The ends of adjoining sheets should lap 6 inches. The edges of the 2- and 3-crimp sheets should lap over 1 crimp, and those of the 4-, 5-, and 6-crimp sheets should lap over 2 crimps. It is advisable where durability is a factor to use only the heavier weight heavily galvanized metal and not to paint the roofing for 1 year

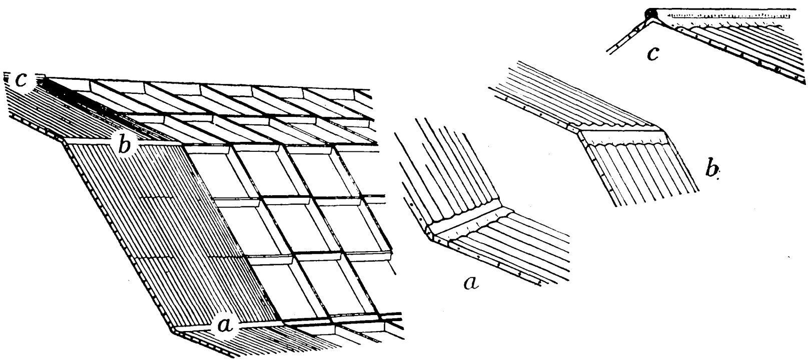

FIGURE 16.—Corrugated metal roof without sheathing: *a*, Eaves joint; *b*, hip; *c*, ridge cap. Note how the headers are staggered to permit nailing through the rafters.

after it has been laid. Wood strips are not generally used under the center crimps.

CORRUGATED SHEET STEEL

Corrugated galvanized-steel roofing is often used on farms. The corrugations add stiffness to the sheets and permit omission of sheathing, which lowers the cost of the roof but provides no insulation against either cold or heat. This type of roofing is available with 1¼- and 2½-inch corrugations, in sheets 26 inches wide and in lengths of from 5 to 12 feet. The width of a sheet will cover 24 inches.

When no sheathing is used the steel sheets are laid on rafters spaced 2 feet on centers with 2 by 4 inch headers cut between them (fig. 16). Sometimes the rafters are covered with 1 by 4 inch roofing slats spaced 2 feet apart. These should be of sound, dense wood to give the nails proper anchorage against wind. When close sheathing is used it should be covered with rosin-sized sheathing paper. The sheets should be lapped 6 inches at the ends and one

and one-half corrugations at sides, and fastened with nails 8 inches apart, driven in the tops of corrugations. Lead washers under the nail heads, or special nails with lead-protected heads, must be used. All laps should be made over supports, and flashings at hips, valleys, eaves, chimneys, etc., should be of galvanized metal supported throughout their entire length. Open valleys should be used and lined with galvanized metal 1 or 2 gages heavier than the main roof. Valleys may be formed by laying 1 by 4 inch strips on each side of the center line and not less than 4 inches apart. The metal lining is supported at the sides by these strips and bent down in the center to form a channel for the water. Roof sheets can be sprung slightly, to fit the edges of the valley.

Special ridge rolls and joints and flashings for use at hips, eaves, and chimneys are made for use with this type of roofing and aid in building a tight roof. The V-crimp sheets make a nicer appearance than corrugated metal and can be used instead of it when close sheathing is provided. More detailed instructions for laying steel roofing may be obtained from manufacturers.

Corrugated-metal roofings of sheet zinc, and asbestos-coated metal, are used on some industrial buildings subject to specially deteriorating conditions, but are more costly than steel.

CANVAS ROOFING

Canvas roofing has been used for years where a flat roof must be walked upon. It is light in weight, not readily broken under light traffic, long-lived and watertight when kept well painted, and not difficult to lay. It is frequently used along the seacoast and for covering boat decks and railroad cars.

This type of roofing is relatively high in cost but is not expensive considering its durability under the severe service generally imposed upon it.

Canvas, called by manufacturers "cotton duck", is made in two general classes, the "numbered duck" and the "ounce duck", the distinction depending upon the method of weaving. Numbered duck is designated by numbers and the ounce duck by ounces. The highest number, 12, is the lightest and weighs 7 ounces per linear yard 22 inches wide, while the lowest number, 00, weighs 20 ounces; the weights of consecutive numbers increase by 1 ounce from no. 12 to no. 00. Ounce ducks weigh from 6 to 15 ounces per linear yard 28½ inches wide and are made in three grades, army, double filled, and single filled. The last two grades are not suitable for roofing but are generally used for awnings.

For roofing the canvas should be unbleached, unsized, and closely woven, and not lighter than the 10-ounce grade, although no. 6 and no. 2 are recommended where there is to be much walking on the roof. Canvas can be had in different widths up to 120 inches; the 22- and 28½-inch widths of numbered and ounce duck, respectively, are commonly used for roofing.

The surface upon which the canvas is to be laid must be smooth and tight. It is advisable to use tongue-and-groove flooring 2½ to 4 inches wide. Sheathing 6 to 8 inches wide could be used but is not so good because of greater shrinkage. If the boards cup or warp, the raised edges will make ridges which will wear through the canvas.

In laying a canvas roof the wood sheathing should first be painted with a paint made on the following basis, if a light-colored roof is desired: 100 pounds of white lead in oil heavy paste, 4 gallons of raw linseed oil, 2 gallons of turpentine, and 1 pint of liquid drier.

When this paint is thoroughly dry, a heavy coat of the white lead heavy paste should be applied. The canvas should be placed on the surface and firmly pressed down into the wet paste; a smoother surface is obtained if the canvas is pressed down with rollers. The canvas should be nailed with 3/4-inch copper tacks, three-fourths of an inch apart. The edges of adjacent strips of canvas should be painted and lapped 1 1/2 inches. Flashings of canvas are installed in the same manner as flashings of other material.

After the canvas has been laid the exposed surface should receive three coats of paint. The priming coat should be mixed on the following basis: 100 pounds of white lead in oil heavy paste, 3 gallons of raw linseed oil, 2 gallons of turpentine, 1 pint of liquid drier. The second and the finishing coats may be any good paint designed for outside use. The drier may be omitted from the bedding and priming coats if ample time is available for drying, say a week, between coats.

Another method often used in placing the canvas is to stretch it tight and nail it in place, omitting the paint on both the under side and on the sheathing. The canvas is then soaked with water. As soon as the surplus water has disappeared, but while the canvas is still wet, it is painted. The same paints may be used as recommended for the first method of laying, and the priming coat should be well worked into the canvas. A good result has been obtained by painting the sheathing as in the former method, wetting the canvas and stretching it on the wet paint, and working in the priming coat when the canvas has partly dried out.

If kept well painted, a canvas roof should last 25 or 30 years.

REPAIRING ROOFS

LOCATING LEAKS

Periodic inspections should be made to detect breaks, missing shingles, choked gutters, or damaged flashings, and also defective mortar joints of chimneys, parapets, coping, etc. At the first appearance of damp spots on ceilings or second-story walls, a careful examination of the roof should be made to determine the cause, and the defect should be promptly repaired. When repairs are delayed, small defects extend rapidly and involve not only the roof covering, but also the sheathing, framing, and interior finish.

Many of the small defects that occur can be readily repaired by a practical man so as to keep water from the interior and to extend the life of the roof. Large defects or failures should be repaired by men familiar with the work because on many types of roofs an inexperienced man can do more damage than he is likely to repair.

Leaks are sometimes difficult to locate, but an examination of the wet spots on a ceiling furnishes a clue to the probable location. If near a chimney or exterior wall the leak is probably due to defective or narrow flashing, loose mortar joints, or dislodged coping. On flat roofs the trouble may be due to the downspouts being choked, or to

an accumulation of water or snow on the roof higher than the flashing. On sloping roofs at valleys and at the junction of dormers with the roof, corroded, loose, or displaced flashing and rotten shingles may be found. Defective and loose flashing is not uncommon around scuttles, cupolas, and plumbing vent pipes. Roofing deteriorates more rapidly on a south than on a north exposure, which is especially noticeable when wood or composition shingles are used. The south slope of a roof should be watched closely for leaks.

Wet spots under plain roof areas are generally caused by holes in the covering. Frequently the drip may occur much lower down the slope than the hole. Where attics are unsealed and roofing strips have been used holes can be detected from the inside by light shining through. If a straw is stuck through the hole it can be located from the outside. Sometimes gutters are so arranged that when choked they overflow into the house, or ice accumulating on the eaves will form a ridge which backs up melting snow under shingles. Leaky downspouts permit water to splash against the wall and the wind-driven water may find its way through a defect and wet the interior.

REPAIRING SMALL DEFECTS

The exact method to use in repairing depends on the kind of roofing and the nature and extent of the defect. The methods of installing flashings and the recommendations for making roofs of different materials watertight are given later.

Missing shingles may be replaced with similar shingles, pieces of rust-resistant metal, or in cases of emergency a temporary repair can be made with metal cut from a tin can. The metal should be painted on both sides and slipped under the shingles in the upper layer, care being taken not to dislodge or loosen sound shingles. Old nails can be cut out with a long, thin cold chisel. After the repair has been made exposed nails should be covered with roofers' cement.

Small holes in metal roofing should be closed with a drop of solder, and larger ones with a patch of the same kind of roofing soldered over the hole. When soldering tools are not at hand small holes may be readily sealed with a plug of elastic roofers' cement and larger holes by pasting a piece of canvas (or several thicknesses of cloth from a cement sack) over the hole and thick paint used for the adhesive and several coats of paint applied on top. This latter method is effective also for large holes corroded in gutters and downspouts.

When metal roofing is riddled with small pinholes and it is not feasible to reroof for several years, an application of a thick bituminous or asbestos coating painted on may be effective. These materials are readily available at builders' supply houses, and are sometimes used on roll roofing and composition shingles when the surfaces have been worn fuzzy by the elements. Asphalt coatings should not be used on tarred felt nor should coatings having a tar base be used on asphalt felt. The type of coating may be identified by the brand name, if known, or dealers can usually tell from a sample.

Holes in built-up roofing are difficult to locate but are readily repaired. Leaks generally occur in sinks or low places in the roof, and usually the area in their locality remains damp longer than sound areas. The loose gravel or slag should be swept aside for later use and the various layers of felt and tar coatings cut out.

Care must be taken not to rip the covering so as to involve too large an area. The layers should be cut out in steps so that the bottom layer has the smallest area and the succeeding layers will lap over the next lower by 1 to 2 feet, thus preventing a hump when the patch is completed. The patches must be embedded in hot tar or asphalt, and a generous application of the tar poured over the last layer for embedding the gravel. The life of a built-up roof can be considerably extended if, after years of service, the loose gravel is scraped off, the roof recoated with tar or asphalt, and the gravel replaced before the coating has hardened (fig. 17). If a built-up roof needs repairs in many places it is frequently advisable to put on a new roof.

FIGURE 17.—Resurfacing a built-up roof: *A*, Sweeping off loose gravel; *B*, sweeping off dust and sand; *C*, pouring on hot asphalt.

When repairing any type of roofing, loose flashing should be securely fastened in place and joints filled with roofer's cement, or, if the joint in which the flashing is anchored is wide, oakum rolled in roofer's cement and calked in the joint will prove economical and effective. The metal of open valleys, if badly corroded, should be replaced with new metal. Closed valleys are more difficult to repair, and if it is not feasible to slip pieces of metal up under the

shingles where leaks occur the services of a roofer should be obtained. Square pieces of metal folded on the diagonal should be used so that the wedge-shaped point may be slid past nails.

Loose mortar of chimneys should be raked out and the joints repointed with a mixture of 1 part portland cement, 1 part lime, and 6 parts sand.

As a safety measure to the person repairing a roof, scaffolds, ladders, or a rope should be provided. Several types of scaffolds are shown in the illustrations of this bulletin. Soft-soled shoes should be worn when working on a roof to avoid breaking the roofing material.

CONSIDERATIONS IN SELECTING ROOFING

Each type of roof covering has characteristics affecting its selection for use under certain conditions, some of which are listed in table 3.

TABLE 3.—*Recommended minimum roof slope, and approximate weights and costs of various roof coverings* [1]

Type of roofing	Minimum allowable slope per foot, with ordinary lap	Approximate weight per square	Approximate cost per square [2]	Type of roofing	Minimum allowable slope per foot, with ordinary lap	Approximate weight per square	Approximate cost per square [2]
	Inches	*Pounds*	*Dollars*		*Inches*	*Pounds*	*Dollars*
Asbestos shingles:				Roll roofing, 2- to 4-inch lap	3	100	3 to 5
American pattern	6	500	18 to 25	Roll roofing, 17- to 19-inch lap	½	200	6 to 10
Dutch pattern	8	300	12 to 17	Slate	6	800	15 to 25
Hexagonal pattern	8	275	11 to 16	Tin:			
Asphalt shingles	6	200	5 to 10	Standing seam	3	75	12 to 20
Built-up roofing	½	650	6 to 18	Flat seam	½	75	12 to 20
Canvas 8 to 12 ounce	½	25	8 to 13	Wood shingles	6	200	6 to 10
Galvanized steel:							
Corrugated	3	100	6 to 9				
V-crimp	2½	100	7 to 10				

[1] These costs are for plain roofs. Cost is considerably increased by breaks in the roof.
[2] Local availability of a material may result in lower prices than those shown.

Ordinary wood shingles when laid with 4, 4½, or 5 inches of exposure require approximately 900, 800, and 720 shingles, respectively, to lay 100 square feet of plain roof. Additional allowances must be made for waste, hips, valleys, and starter courses. This applies in general to all types of roofing. Roofings other than wood shingles are commonly sold by dealers or manufacturers on the basis of quantities sufficient to cover 100 square feet of roof area.

The slope of the roof and the strength of the framing are the first determining factors in choosing a suitable covering. If the slope is slight there will be danger of leaks with a wrong kind of covering, and excessive weight may cause a sagging which is unsightly and adds to the difficulty of keeping the roof in repair.

The cost of roofing depends to a great extent on the type of roof to be covered. A roof having many ridges, valleys, dormers, or chimneys will cost considerably more to cover than one having a plain surface. Very steep roofs are also more expensive than those with a flatter slope. Frequently proximity to supply centers will permit the use, at a lower cost, of the more durable materials instead of shorter lived materials that are commonly sold at a lower price.

In considering cost, one should keep in mind maintenance and repair and the length of service expected from the building. A permanent structure warrants a good roof even though the first cost is somewhat high. Where the cost of applying the covering is high in comparison to the cost of the material, or when access to the roof is hazardous, one is warranted in using material having a long life. Unless insulation is required, semipermanent buildings and sheds are generally covered with low-grade roofing.

Frequently the importance of fire resistance is not recognized, and at other times it is wrongly stressed. It is essential to have a covering that will not readily ignite from glowing embers,[6] but unless proper precautions against inside fires have been provided a noncombustible roof is not necessary except where it is exposed to sparks, as from passing locomotives. The building regulations of many cities prohibit the use of certain types of roofings in congested areas where fires may spread rapidly. Farm buildings generally are isolated, and if the roof surfaces are kept smooth and in good repair most of the coverings commonly used in rural sections afford reasonable protection. The National Board of Fire Underwriters have grouped many of the different kinds and brands of roofing in classes according to the protection afforded against spread of fire.

The appearance of a building can be materially changed through the use of the various coverings in different ways. Wood shingles and slate have an inherent beauty that permits a latitude in producing architectural effects. The roofs of buildings in a farm group should harmonize in color even though similarity in contour is not always feasible.

The action of the atmosphere in localities where the air is polluted with fumes from industrial works or is saturated with salt, as along the seacoast, shortens the life of roofings made from certain metals. Roofings having an iron base, even though galvanized, are particularly susceptible to such corrosion, and if used they should be kept well painted; copper and zinc are much more durable in such localities.

Tar and asphalt roofs, especially in hot climates, should be covered with slag or a mineral coating, because where fully exposed to the sun these materials deteriorate rapidly. Observation has shown that, in general, roofings with light-colored surfaces absorb less heat and consequently last longer than those with dark surfaces.

Considerable attention should be given to the comfort derived from a properly insulated roof.[7] A thin uninsulated roof affords little protection to the interior from summer's heat and winter's cold. Discomfort from summer heat can be alleviated to some extent by ventilating the space under the roof. Corrugated metal, when used on animal shelters, should be insulated to prevent moisture condensing on the under side. If it is necessary to reroof, consideration should be given to the insulating value of the covering and to the feasibility of installing extra insulation under the roofing. Manufacturers of insulation usually furnish directions for using their products.

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[6] See Farmers' Bulletin 1590, Fire-Protective Construction on the Farm, pp. 7–8.

[7] See U S. Department of Commerce, National Committee on Wood Utilization, Report 25, Insulation on the Farm. For sale by the Superintendent of Documents, Government Printing Office, Washington, D.C., price 10 cents.

REROOFING OVER OLD ROOFING

When the nature of the new roofing permits it to be laid over the old covering, the advantages gained are that the work can be done without exposing the interior of the building to the weather, the old roofing provides additional insulation, and the labor and mess incident to removal are avoided. Before selecting the new covering, however, the roof framing should be examined to determine whether it has sufficient strength to carry the additional weight. Slate, clay tile, and asbestos shingles are heavy; and when they are used, the rafters may require bracing. When the framing cannot be properly braced, it may be necessary to remove the old covering to lessen the load. It is advisable, and in most cases necessary, to remove metal coverings; also if slate or other brittle roofings are selected the old covering should be taken off so as to provide a smooth deck, because any unevenness will cause breakage and waste.

There is a decided advantage in not removing old roll roofing and composition shingles, especially when reroofing with rigid shingles or metal, provided the old covering is not "puffy" or badly wrinkled and the framing will sustain the additional weight. Puffy areas should be slit or cut so that the old roofing may be nailed flat. Where metal is used for the new covering, rosin-sized paper should be laid over the old surface. Where roll roofing or composition shingles are to be used for the new roof, it is good practice to coat the old surface with a bituminous dressing just prior to laying the new material so as to cement the two coverings together. Old nails at the eaves may have to be removed and new strips of wood fastened under the edges of the sheathing to provide for secure nailing when turning down the edges of the roofing. If the new strip is not provided, the additional nails may split the edges of the sheathing and permit the wind to blow under the new covering.

In preparing an old wood-shingle surface to receive a new covering, all curled, badly warped, and loose shingles should be nailed flat and secure, and all protruding nails should be driven down. The various steps are shown in figure 18. The old shingles along the edges of eaves and gables, for a distance of from 4 to 6 inches, should be removed to permit the installation of a wooden strip or slat so as to hide the layer of old shingles at the edges of the roof, and open valleys should be filled in with wood strips level with the old shingle surface. A much better surface is provided if beveled strips about 4 inches wide are nailed over the exposed butts of the old shingles. The use of these strips increases the cost somewhat, but they aid materially in keeping the old shingles flat and loose shingles in place, supply additional insulation, and provide a much smoother surface which facilitates laying the new covering and helps to prevent it from being damaged while being laid.

ROOFING DETAILS

NAILS

Experience has proved the wisdom and economy of rust-resistant nails. The maximum service cannot be secured, from even low-grade roofing, when light-weight steel nails are used. Use only copper, heavily galvanized cut nails, or nails of the special type recommended by the manufacturers of the roofing. Nails should be long enough to penetrate about three-fourths the thickness of the sheathing.

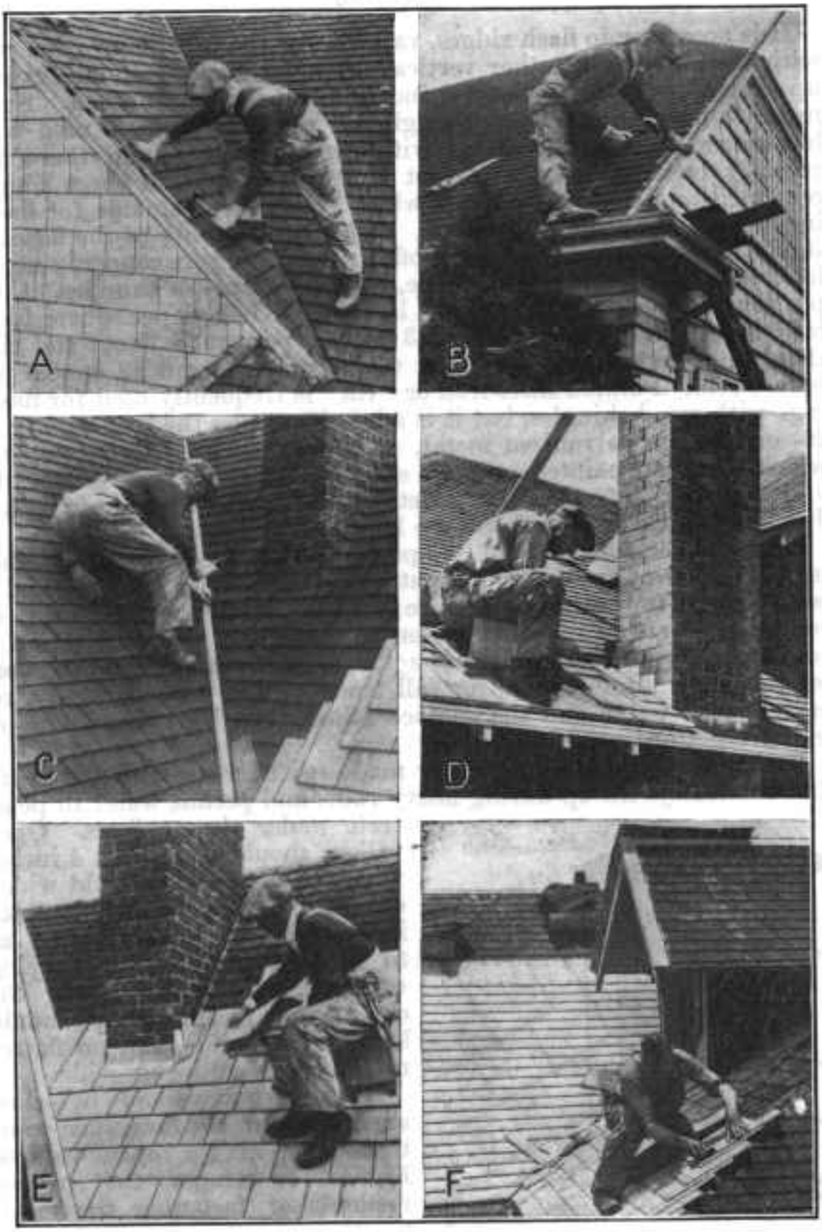

FIGURE 18.—The different steps in laying new shingles over old ones; *A*, Cutting away old shingles at gables to provide for nailing strip. The old shingles could be sawed off flush with the cornice and a suitable strip applied to the side, the top even with the old roof. *B*, nailing strip at gable edge. *C*, Filling in an open valley. *D*, Placing new shingles; note double course at eaves. *E*, Note new chimney flashing and temporary wood strip in valley for lining up shingles. *F*, Note strips of bevel siding laid, thin edge down, to provide for solid nailing at ridge. Similar strips are sometimes used over each course of butts to provide a smooth surface for other types of roofing.

FLASHING

It is necessary to flash ridges, valleys, and the junctions of the roof with the chimney or other vertical surfaces; flashing should extend up vertical surfaces at least 6 inches and be counterflashed. Sheet metal is usually employed, though roll roofing or felt is used with bituminous coverings, canvas with canvas roofing, and there has recently been put on the market a new type of thin sheet copper cemented to a composition base which may prove valuable for flashings with other roofing materials. The lasting quality of the flashing should be equal to that of the roofing; therefore soft copper, zinc, or hard lead should be used with tile, slate, and asbestos shingles. Copper for flashing should weigh not less than 16 ounces per square foot; lead should weigh not less than 3 pounds per square foot; and zinc should not be lighter than no. 9, which weighs about 12 ounces per square foot. Painted sheet iron or "tin" is frequently used for flashings with wood shingles, but it is advisable to use the best quality of 26- or 24-gage galvanized metal, or heavily coated IX flashing tin which has been painted on both sides with red lead, or one of the higher-priced materials. Like metal roofs, exposed parts of the less durable metal flashings should be kept painted.

Copper is seldom painted except to prevent the staining of other surfaces. Paint applied to untreated copper will not last long and it is advisable to wash the surface with a solution of 4 ounces of copper sulphate in one-half gallon of lukewarm water to which is added one-eighth ounce of nitric acid. (Glass vessels should be used for mixing.) Before painting, all traces of the acid should be removed with water and the surface allowed to dry. Sheet zinc or lead are not ordinarily painted.

Valley flashings are frequently made too narrow, with the result that the valleys fill up during heavy rains and permit water to penetrate under the roofings. Open valleys should be at least 4 inches wide at the top and should widen out at the rate of one-sixteenth inch per foot of length so as to increase their water-carrying capacity. On roofs sloping 45° or more the flashing strips should be 18 inches wide, and on flatter roofs at least 20 inches wide.

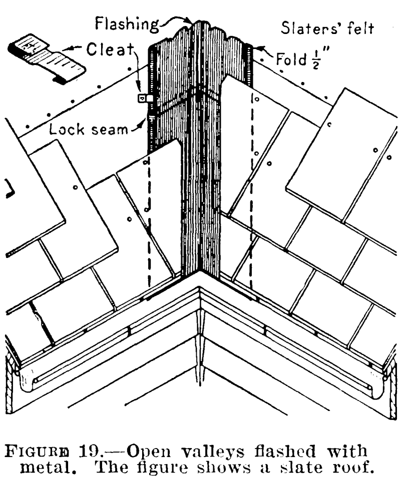

FIGURE 19.—Open valleys flashed with metal. The figure shows a slate roof.

The cross seams should be locked and soldered to form one continuous strip for open valleys. Figure 19 shows the proper methods of fastening the metal to the sheathing with cleats. Closed valleys where slate or asbestos shingles are used may be flashed with a continuous metal strip under the shingles (fig. 20, *A*) or by building in short pieces of metal as the shingles are laid (fig 20, *B*). Where nail holes of slate or asbestos shingles come over the metal, new holes should be provided in each slate so that it can be secured by two nails located

outside the metal. It is good practice to embed the edges of slate, etc., that lap the flashing in plastic cement.

When flashing extends up vertical surfaces it must be counter-flashed with cap flashing. The cap flashing should not be fastened rigidly to the base flashing. In masonry walls a groove one-half inch

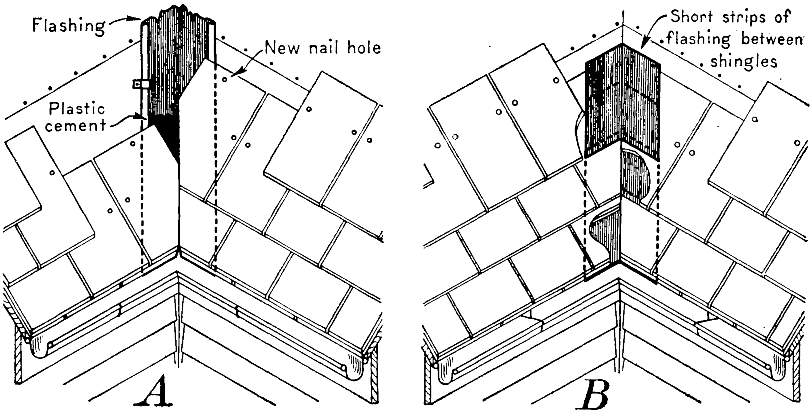

FIGURE 20.—Closed valley flashings: *A*, Long sheets under shingles; *B*, short pieces intermembered with shingles.

high and about 1½ inches deep is provided 6 or more inches above the roof level, into which the cap flashing is folded, wedged, and calked. In brick walls the cap flashing may be built into the joints, or a reglet tile may be used (fig. 12, *A*), and in concrete walls the groove may be formed at the time of pouring the concrete. The method of flashing at a chimney located on the ridge is shown in figure 21. A cricket or saddle should be provided behind[8] a chimney located on a slope, to divert water coming from the upper part of the roof and to prevent ice forming behind the chimney. Plumbing vent stacks should be flashed so as to permit the pipe to settle or expand without causing leaks.[9]

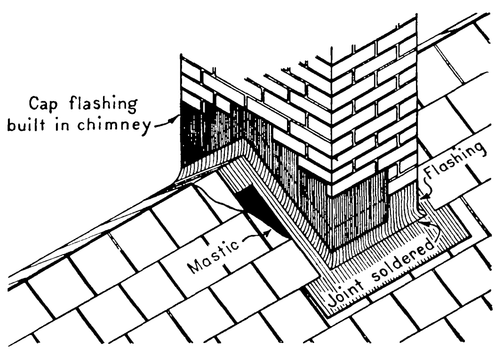

FIGURE 21.—The cap flashing is built into the joints when the masonry is laid, and is folded down at least 4 inches over the base flashing that is installed when the roofing is placed.

GUTTERS AND DOWNSPOUTS

While gutters are not necessary it is advisable to use them to prevent the formation of water holes around the building. If a cistern is used, gutters are imperative. Gutters may be of wood built in (fig. 22) as a part of the cornice and lined with metal, or they may be metal troughs hung along the eaves (fig 23).

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[8] See Farmers' Bulletin 1649, Construction of Chimneys and Fireplaces, fig. 7.

[9] Farmers' Bulletin 1426, Farm Plumbing, fig. 39 illustrates methods of flashing vent stacks.

In regions of large snowfall the outer edge of the gutter should be one-half inch below the extended slope of the roof, to prevent snow banking on the edge of the roof and causing leaks. The hanging gutter is better adapted to such construction.

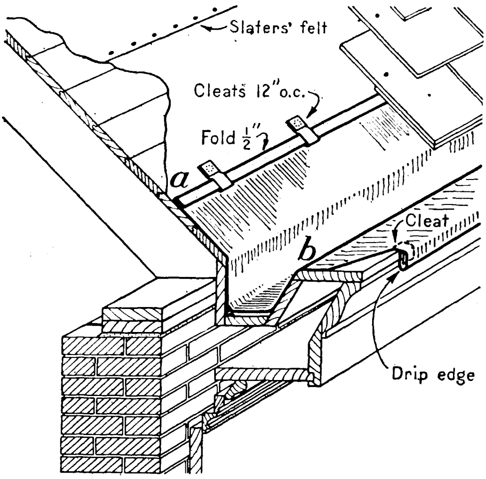

FIGURE 22.—Built-in gutter. Note that flashing should be at least 2 inches higher at *a* than at *b*.

The expense for maintenance can be considerably reduced if the gutters are built in, and are of first-class material, though the first cost is somewhat greater. Built-in gutters should be wide and shallow with the outer face sloped to prevent being broken by ice forming in the gutter, and should be built entirely outside the wall line of the building. Gutters should slope about one-sixteenth inch per foot toward the outlet.

Downspouts (fig. 24) should be large enough to remove the water from the gutters. A very common fault is to make the gutter outlet the same size as the downspout. At 18 inches below the gutter a downspout has nearly four times the water-carrying capacity of the inlet at the gutter; therefore an ample entrance to the downspout should be provided. Conductor heads or funnels are readily available from roofing establishments and should be used where branch downspouts converge or at scuppers of flat roofs. Wire baskets or guards should be used at gutter outlets to prevent leaves and trash collecting in the downspouts.

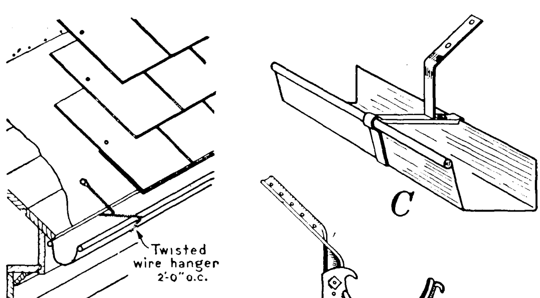

FIGURE 23.—Hanging eaves trough: *A*, Circular section; *B*, adjustable hanger; *C*, rectangular section.

In cold climates where water will freeze, should it stand in the downspouts, the use of corrugated instead of plain metal will save much trouble and probably prevent the pipe's bursting because of expansion.

The lower end of each section of downspout should be fitted inside the next lower section, for if fitted over it water will flow out at the joint. Sometimes the joints are soldered tight, but for general practice this is not advisable because normally slip joints eliminate the necessity of special provision to take care of expansion and contraction. Downspouts should be soldered to the straps which

fasten them to the building. The lower end should be fitted with a shoe or turn-out where the water is to be wasted on well-drained ground, with a cast-iron pipe connection or boot when water is to be diverted into a storm sewer, or with a rain switch or diverter for excluding from a cistern the first portion of each rain.

Intense rains occur periodically in certain localities but do no great harm to the contents or surroundings of farm structures if the gutters overflow for the duration of the storm. For the sake of economy, gutter and downspouts will be ample in size if large enough to carry off only normal storm water flow.

Sizes of downspouts and half-round gutters are suggested as given in table 4 for general farm use.[10] Local conditions may require larger sizes. Downspouts should be placed not over 40 feet apart in the length of a gutter.

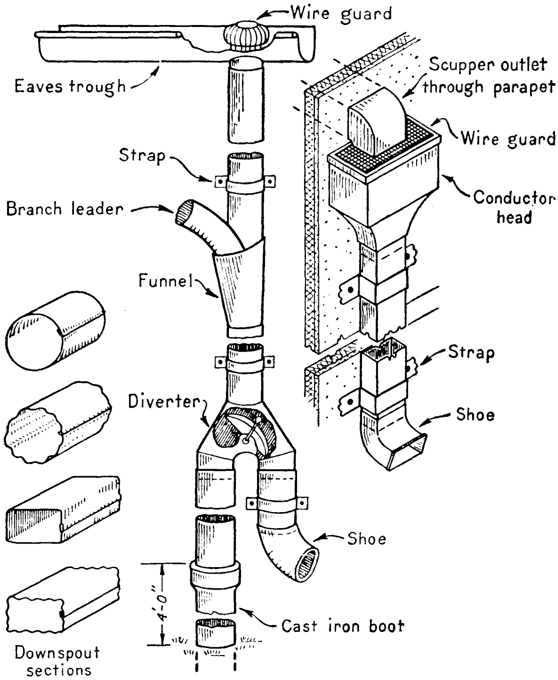

FIGURE 24.—Downspouts and fittings.

TABLE 4.—*Sizes of eaves, troughs, and downspouts for various roof areas*

Roof area (square feet)	Eaves-trough diameter	Down-spout diameter	Roof area (square feet)	Eaves-trough diameter	Down-spout diameter
	Inches	*Inches*		*Inches*	*Inches*
100–800	4	3	1,000–1,400	5	4
800–1,000	5	3	1,400–2,000	6	4

SNOW GUARDS

Snow guards should be used on steep roofs in cold climates, to prevent sheets of ice or snow from sliding. Sliding ice frequently will tear off the roof covering, break gutters, or imperil the life of a person walking under the eaves. Figure 25, *A*, illustrates several common types of guards which can be secured to the sheathing so as to project through the joints in the roofing. The guards

[10] See Farmers' Bulletin 1572, Making Cellars Dry, pp. 3–8, for a fuller discussion of downspouts.

should be staggered in three rows near the eaves and 6 to 12 inches apart, though they are often located only over entrances or at traveled places. Figure 25, *B*, illustrates a practical home-made type that can be installed without puncturing the roofing.

UNITS OF ROOF MEASUREMENT

The slope may be indicated in 1 of 3 ways: (1) The number of inches' rise in 1 foot of horizontal distance; (2) the pitch, or ratio obtained by dividing the rise of a rafter by twice its horizontal run; (3) the angle in degrees between the roof surface and the horizontal. The distance from the plate to the ridge measured along the rafters for a definite span depends on the slope of the roof. Table 5 will be helpful in estimating roof areas.

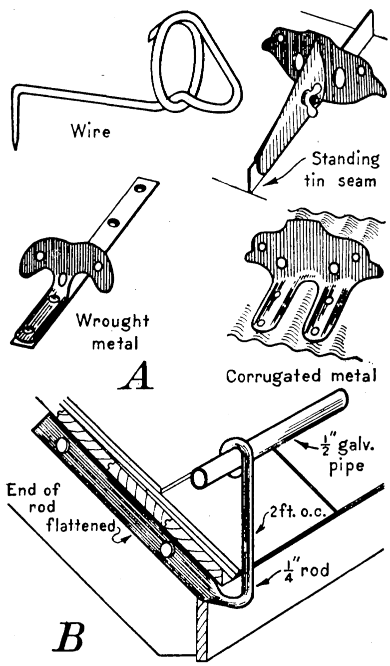

FIGURE 25.—Snow guards: *A*, Common types installed at time of placing roof covering; *B*, home-made type.

TABLE 5.—*Unit measurements for use in determining roof areas*

Inches rise per foot horizontal	Pitch	Angle with horizontal		Inclined area per square foot of horizontal area
		Degrees	*Minutes*	
½	1/48	2	23	1.001
¾	1/32	3	35	1.002
1	1/24	4	46	1.003
1½	1/16	7	8	1.008
2	1/12	9	28	1.014
3	1/8	14	2	1.031
4	1/6	18	26	1.034
6	1/4	26	34	1.118
8	1/3	33	42	1.202
12	1/2	45	0	1.414
14		49	24	1.537
18		56	19	1.803
24	full	63	26	2.235

The area in square feet of a plain gable roof can be determined by multiplying the number in the last column (corresponding to the pitch) by both the length and width of the building and adding thereto the area of the projecting eaves and gables. The areas of roofs broken by dormers, etc., can be found in a similar manner by determining the area of each part of the roof separately.

When estimating amount of roofing needed, allowance should be made for the extra quantities that will be needed for fitting around chimneys and dormers and at valleys. The extra amount needed depends on the type and size of the units and the plainness of the roof. In order to obtain enough material the purchaser should have someone familiar with estimating determine the amount required.

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